Technical Note

Interpreting MoviTools® Scope

The MoviTools® Scope program is an oscilloscope for SEW drive inverters. It enables a technician to tune SEW inverters and to analyze system performance during troubleshooting. Using the scope program, the user can obtain the system values, store them into the inverter, download them into a computer, and then display them in a graphical format for interpretation.

An understanding of the basic operation of a PI Loop and its parameters should assist the user in interpreting the graphical scope trace.

What is a PI Loop?

Internally, Movidrive® inverters contain a PI (Proportional-Integral) loop for speed control, similar to cruise control in an automobile. At a given moment in time, a PI Loop measures the motor's actual speed and compares it to the desired setpoint speed. The difference is the error, as shown in Figure 1. Based upon this difference, the error correction process of the PI Loop makes appropriate adjustments to the drive's performance, with the goal of having zero error and having the actual speed equal to the desired speed at the next measurement.

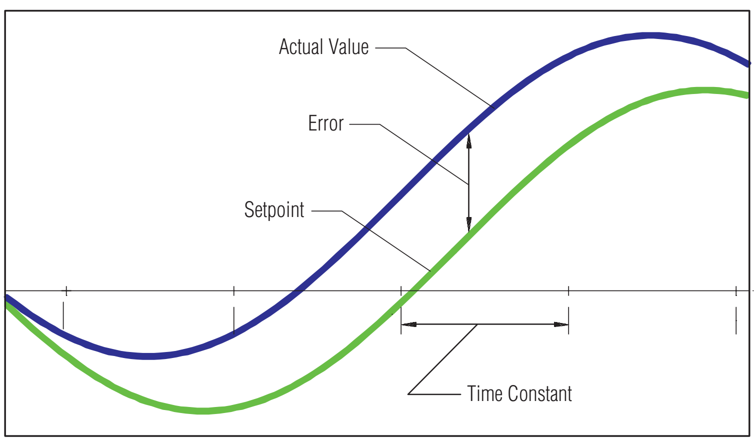

Figure 1: Error and Time Constant

MoviTools® Scope program contains several system values available for display. The three main values used for diagnosis and tuning are setpoint speed, actual speed, and active current.

Active current is a demonstration of how "hard" the motor has to work in order to run at the desired speed. Active current is not the total current. Rather, it is a portion of the total current – the portion that produces torque in the motor. Active current should fluctuate only slightly during periods of constant speed. However, larger current fluctuations are normal when the motor changes speed or direction.

Manually changing some inverter parameters to alter the error correction process is known as tuning. Ideally, the drive's actual speed should be as close as possible to the setpoint speed at all times with little or no fluctuations in active current.

Tuning Parameters

There are four parameters that influence the error correction process: P-gain, Time constant, Stiffness, and Load Inertia.

- **P-gain** is the error multiplication factor. P-gain can be compared to the gas and brake of a car. A high P-gain tries to make an abrupt speed change and is similar to pushing the accelerator to the floor or slamming on the brakes. A low P-gain is similar to giving a little gas or lightly tapping the brakes. MoviTools® allows the entry of P-gain either during startup or from the parameters.

- **Time constant** is the rate of error correction. It is the amount of time that actually passes between each error correction, as shown in Figure 1. The Time constant is similar to how often a person looks at the speedometer in order to speed up or slow down. MoviTools® allows the entry of Time constant either during startup or from the parameters.

- **Stiffness** adjusts P-gain and Time constant simultaneously. Increasing stiffness increases P-gain and decreases Time constant. Decreasing stiffness decreases P-gain and increases Time constant. A small change in stiffness can change the operation drastically. Therefore, increments of 0.01 are recommended for stiffness adjustments.

- **Load Inertia** affects the P-gain and Time constant. The greater the inertia, the more the load resists a change in motion. During the load inertia testing procedure, the inverter measures the inertia reflected onto the motor shaft and calculates the P-gain and Time constant automatically. If necessary, the user may also enter the value of the load inertia manually.

Having the right combination of Proportional gain and Time constant values is key for a properly tuned drive. The following illustrations are scope traces showing examples of excellent control and poor control. Extreme parameter settings were used when taking some of these traces in order to provide clear understanding and illustration. In reality, only small adjustments are usually necessary with proper sizing and setup of the Movidrive®.

Excellent Control

Figure 2 shows the scope trace of a properly tuned inverter using the following color scheme.

- Blue = Actual Speed
- Green = Setpoint Speed
- Red = Active Current

Notice that there is little separation between the blue and green lines, indicating that the actual speed very closely matches the desired setpoint speed. The black arrows indicate two instances of separation: one when acceleration begins (speed increases), the other when acceleration stops (speed is constant). However, these differences are quickly corrected, showing excellent control.

In addition, this scope trace shows little fluctuation of the active current, another indication of excellent control. It also shows higher current during acceleration, which is normal because more torque is needed during acceleration that during constant speed.

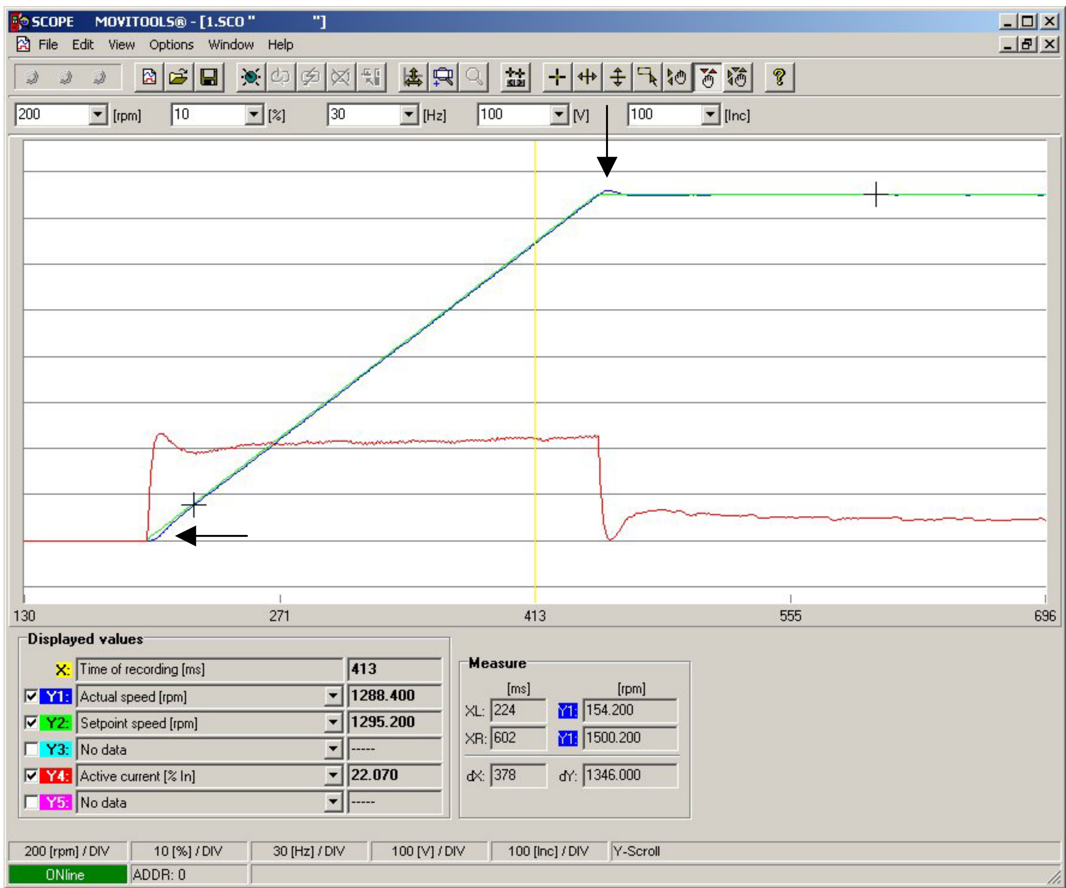

Figure 2: Excellent Control

Spiking Active Current

Figure 3 is an example of a system with poor control. At first glance, it may appear to be excellent, since the actual speed follows the desired setpoint speed exactly. However, the active current fluctuates excessively, indicating that the motor is working too hard to accomplish the setpoint speed. This excess current fluctuation causes increased heat in the motor and shortens the life expectancy of the stator.

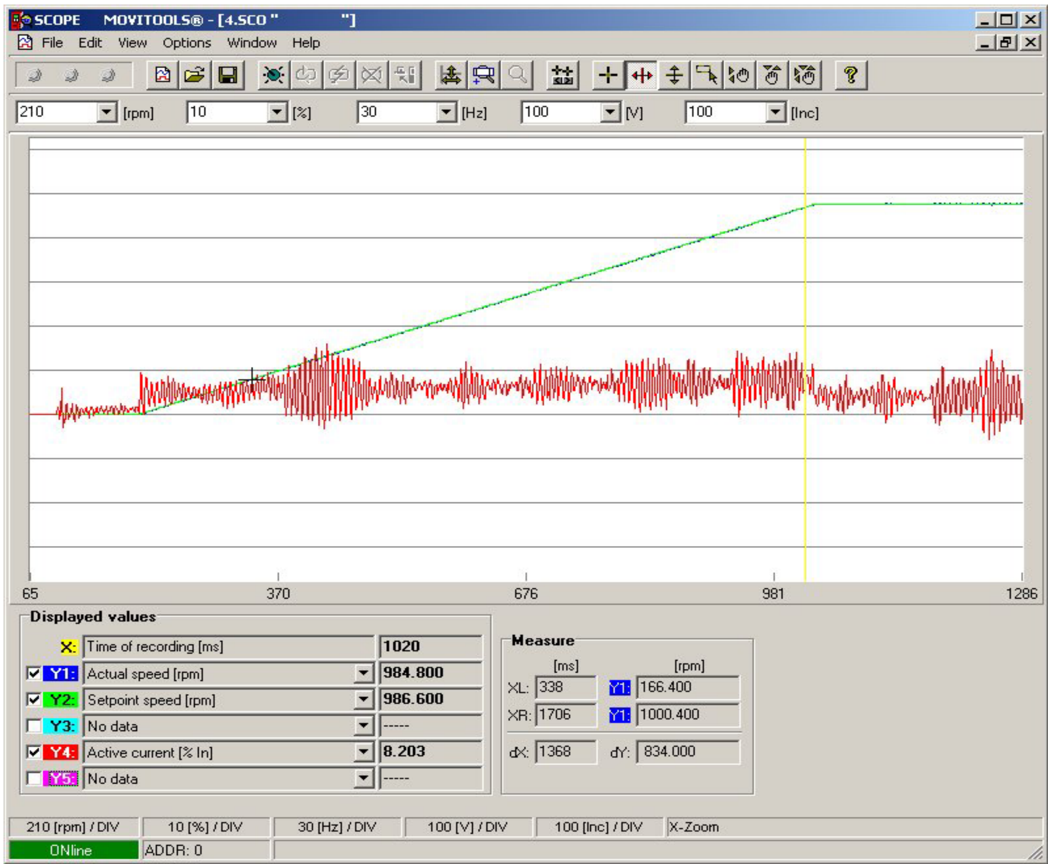

Figure 3: Spiked Current

One or more of the changes below can remedy this situation:

- Lower the P-gain so that the inverter makes softer, less abrupt corrections.
- Increase the Time constant a small amount to decrease the frequency of corrections.
- Lower the Stiffness factor, which lowers the P-gain and increases the Time constant.

Continual Overshoot

Figure 4 shows the trace of a system with continual overshoot and poor control. The blue line greatly oscillates around the green line, showing continual speed fluctuation. In addition, the red current line oscillates like the blue line instead of remaining flat.

This situation occurs with a Time constant that is too high. The inverter is taking too long between corrections. It is similar to not releasing the gas petal once a car accelerates to the desired speed and then not releasing the brake petal once the car decelerates to the desired speed.

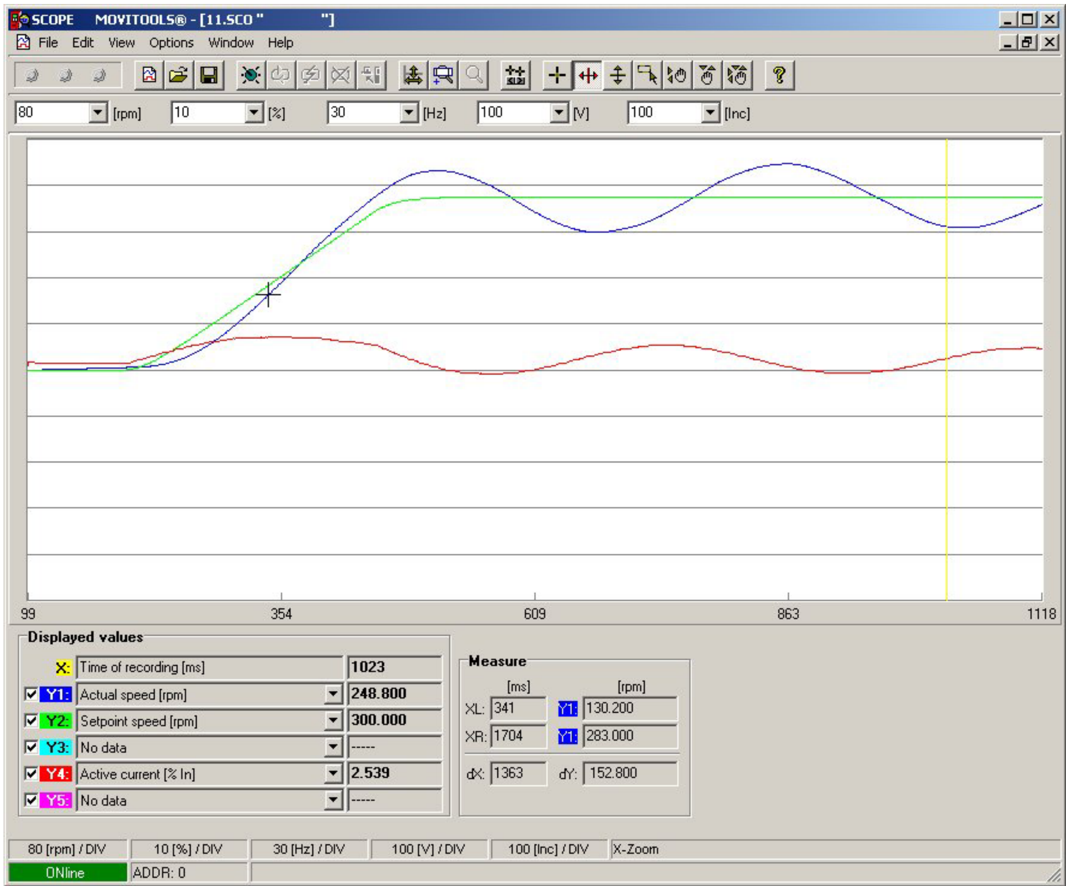

Figure 4: Continual Overshoot

One of the following changes can remedy this situation:

- Decrease the Time constant to increase the frequency of corrections.
- Increase the Stiffness factor, which increases the P-gain and decreases the Time constant.

Continual Undershoot

Figure 5 shows the trace of a system with continual undershoot and poor control, as noted:

- The blue actual speed never approaches the green setpoint speed, indicating a low P-gain. The inverter is taking too long to check for an error and then does little to correct it. This is similar to driving a car at 50 mph in a 60 mph zone, and then pressing lightly on the gas petal to accelerate to 55 mph, but never approaching 60 mph.

- A gentle slope in the active current occurs when the actual speed levels out after acceleration, indicating a high Time constant.

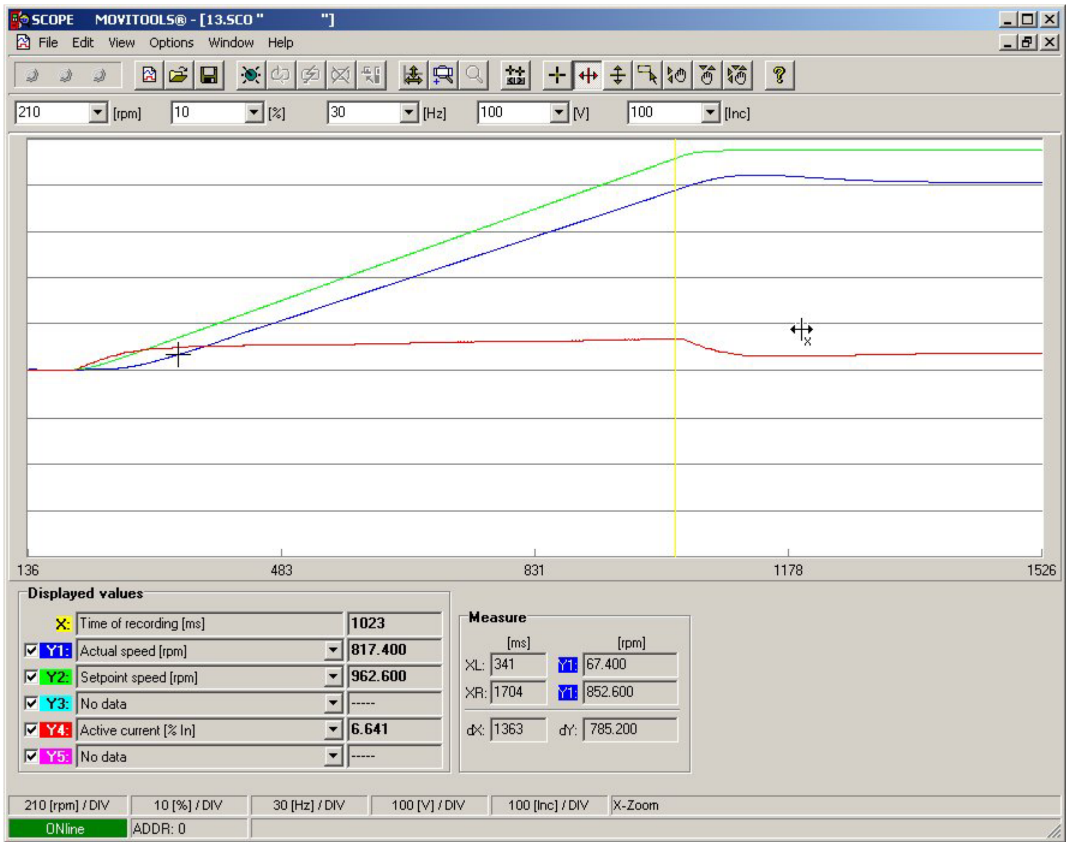

Figure 5: Continual Undershoot

One or more of the following changes can remedy this situation:

- Decrease the Time constant to increase the frequency of corrections.
- Increase the P-gain to increase the amount of correction.
- Increase the Stiffness factor, which increases the P-gain and decreases the Time constant.

Oscillating Speed

The trace in Figure 6 represents less-than-optimal control, but close. Notice how the blue speed line continually jumps above and below the green horizontal setpoint, indicating too frequent error correction. Also, notice how the red active current oscillates at the same rate.

On a positive note, the overshoot above and below the green line is not large. Therefore, the P-gain appears to be only slightly high.

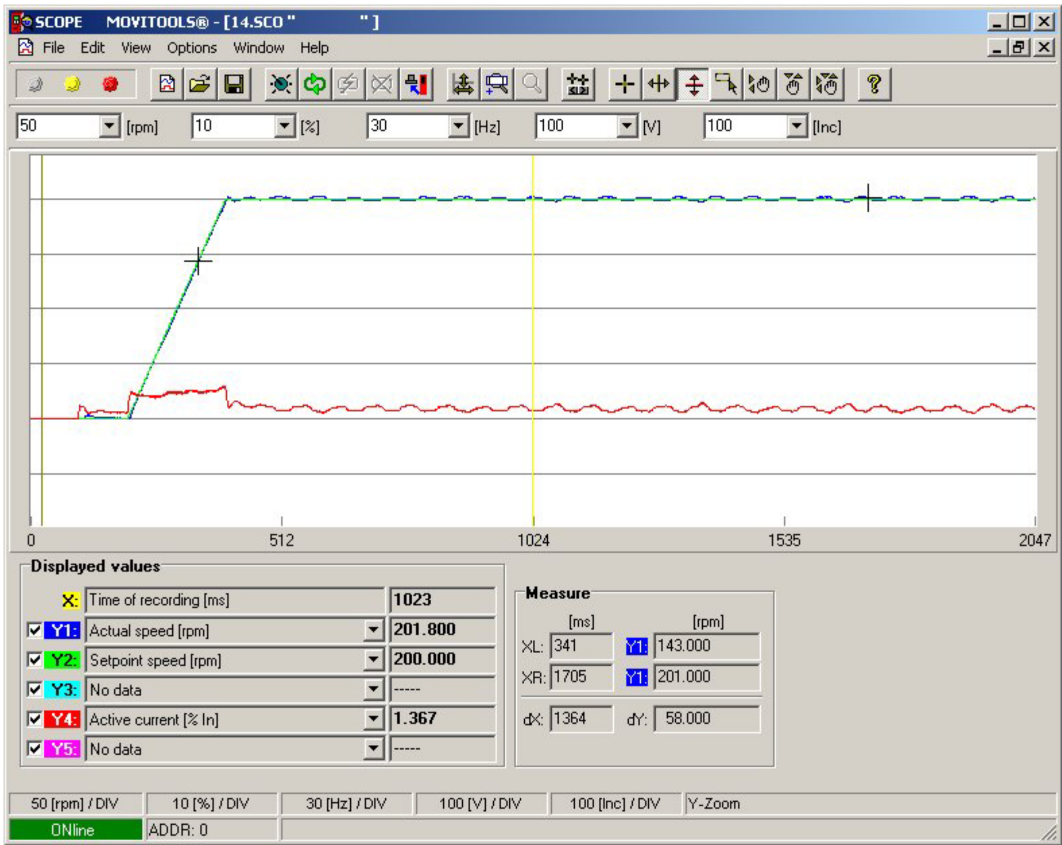

Figure 6: Oscillating Speed

One or more of the following changes can remedy this situation:

- Increase the Time constant a small amount to decrease the frequency of corrections.
- Lower the P-gain slightly to allow the inverter to make a softer correction.
- Decrease the Stiffness factor, which decreases the P-gain and increases the Time constant.

Load Inertia

The previous graphs offer guidance to the user when tuning a system. However, systems that have a significantly higher load inertia than motor inertia are very difficult, if not impossible, to tune. High load-to-motor inertias resist change and cause overshoot during acceleration or deceleration. Inertia ratio is particularly important with indexing applications since the speed changes continually.

In these situations, the best solution is to lower the inertia ratio. For more information on inertia ratio, see Technical Note **GM-039**, Designing for Inertia.